

Displaying Water Quality Standards Information Using Web-based GIS: A Foundation for Water Quality Management

by

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Introduction

The EPA Office of Water is developing data systems that will enable EPA, States, Tribes, and the public to view water quality standards for the surface waters of the United States on the Internet. Water quality standards have been available as parts of detailed State regulations in text form (U.S. EPA, 1999). Since May 1998, the Water Quality Standards Branch of the Office of Science and Technology (OST), in coordination with other EPA offices, has been developing detailed geographic information system (GIS) coverages of waters and their water quality standards, as well as a national Water Quality Standards Database (WQSDB). These products will allow for the display and spatial analysis of water quality standards information. A complete picture of the locations of waters and their standards will help EPA and State and local governments target their management resources more effectively, and will increase and enhance public access to environmental information.

State water quality standards comprise three parts: (1) designated uses (e.g., protection of public water supply); (2) chemical, biological, and physical criteria that support the designated uses; and (3) applicable antidegradation provisions (e.g., no new or expanded discharges to outstanding natural resource waters). The plan to place maps of State water quality standards on the Internet has been divided into two phases for ease of project management. The first phase will focus on creating a web site for display of the water quality standards **designated uses**. Later, **water quality standards criteria** and **antidegradation statement** will be displayed on the web site.

Displaying water quality standards information involves a two step process: (1) locate the waters in each State and define their locations in a GIS, and (2) convert the information in State WQS documents to a database format. Once these two components are in place, they can be linked for presentation via a web (Internet Worldwide Web) interface. This paper focuses on the GIS components of the system, including a MapObjects website application developed to present these data. The database behind the website must be developed in such a manner that water quality standards information can be linked to a GIS via a unique identifier and displayed in a

meaningful way. The GIS component involves locating water quality standards waterbodies in a national surface water coverage such as EPA's Reach File version 3.0 (RF3) or the National Hydrography Dataset (NHD). Both RF3 and NHD provide unique identifiers for the stream segments that constitute the nation's surface water drainage network (Dewald et al., 1996). The GIS component is developed by creating a table that contains the unique identifiers from the surface water coverage and the unique identifiers from the database. This linkage allows for the display of the designated use and criteria attributes.

Purpose of This Paper

The purpose of this paper is to provide an overview of the RF3/NHD mapping side of the Water Quality Standards Database and highlight the status of this nationwide effort as of the Spring 2000. The two integral sides of the mapping process are discussed: the reach indexing or georeferencing leading to the development of the States' water quality designated use coverages and the state review process utilizing the Internet capabilities to develop a web-based water quality standards review site.

What Is Waterbody Indexing?

Waterbody or reach indexing is the process of electronically linking a state's water quality information to EPA's RF3 or the NHD. As shown in Figure 1, each waterbody is linked, or georeferenced, to the appropriate RF3/NHD reaches (Cooter et al., 1998). The waterbody indexing in this particular application involves the integration of two sources—a state's WQSDB or waterbody-level designated use database (the tabular data shown in Figure 3) and RF3/NHD (the stream traces shown in Figure 1). Many other datasets can also be linked to RF3/NHD, such as the locations of permitted discharges, ambient monitoring and effluent data, water supply intakes, and Section 303(d) listed waters. This paper focuses on linking water quality designated use data to RF3/NHD for mapping and spatial analysis.

Advantages of Waterbody Indexing

Waterbody indexing allows states to organize, display, and analyze data on designated use support and impairment at the reach segment level, as well as the causes/stressors and sources of impairment. Thus, states can create detailed maps for basin plans, 305(b) reports, and other public documents. They can perform spatial analysis such as comparing the distribution of impaired waters to land uses. Waterbody indexing also promotes easy aggregation of data to the watershed scale; Figure 1 shows the range of scales that can be mapped, from individual waterbody to an entire river basin. The states and EPA will also be able to present the data to Congress and the public at the preferred level of detail. Many states prefer their data presented at the waterbody level whenever possible rather than aggregated to large watersheds.

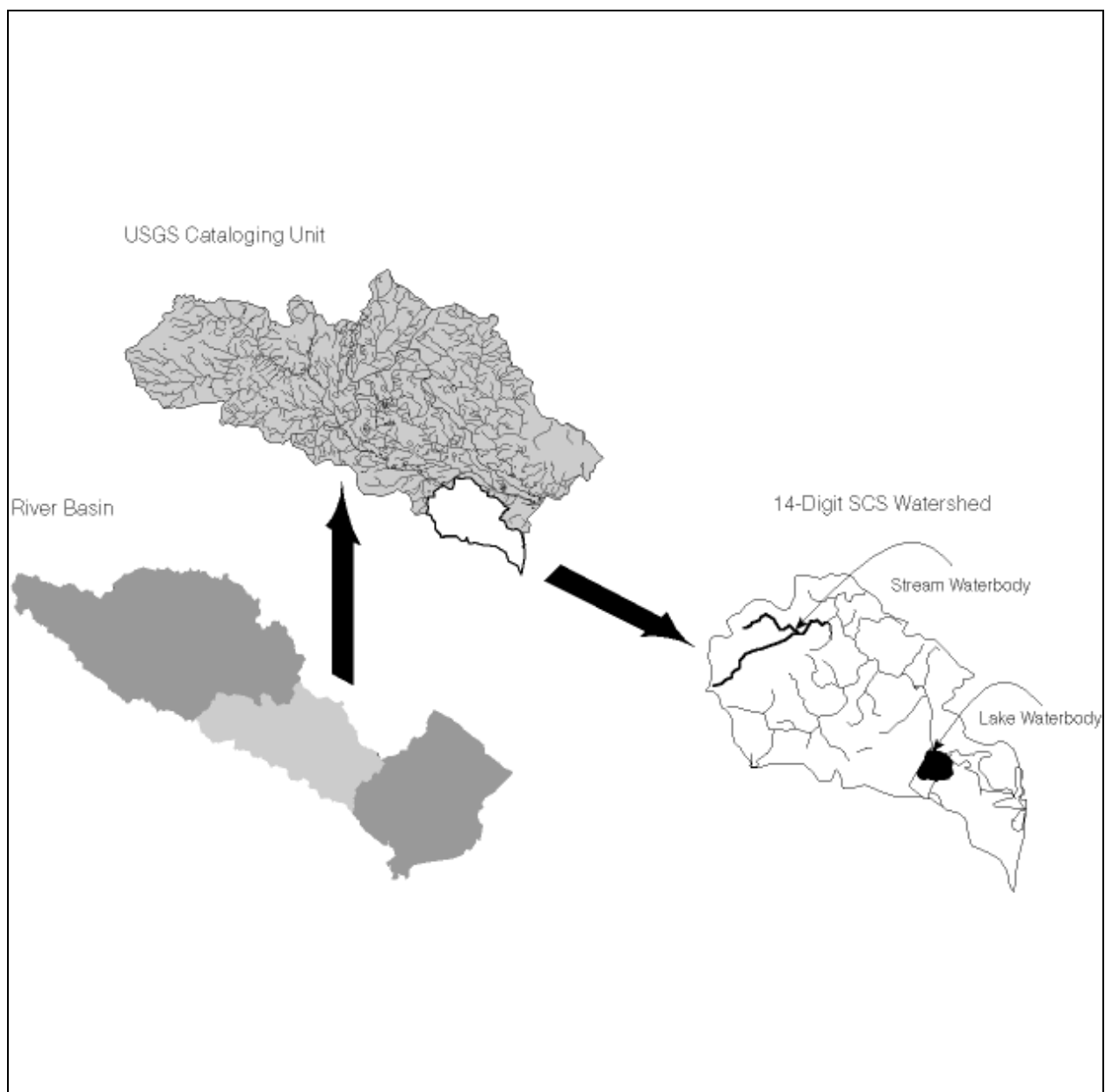


Figure 1. Reach indexing allows states to map water quality data at various levels.

The EPA Reach File (RF3)

RF3 is a hydrographic database containing the geographic coordinates of over 3 million stream, lake, and estuary reaches in the continental United States and Hawaii.

A reach is a stretch of stream between tributary confluences or a segment of lake or estuary shoreline. RF3 provides a unique identification number for any point on these surface water features, a hydrologically connected network of waters, and built-in river mileages. By linking data from their agencies to this nationally consistent network, environmental managers can "navigate" upstream and downstream when assessing the causes and effects of pollution events. For example, the State of North Carolina has used an

RF3-based model to route nitrogen from watersheds throughout the Neuse River Basin to its estuary. RF3 is based on the U.S. Geological Survey's (USGS's) 1:100,000-scale Digital Line Graph hydrography. RF3 has recently been upgraded with the addition of many new features.

The National Hydrography Dataset (NHD)

The NHD is a result of extensive joint efforts by EPA and USGS. It incorporates the best of RF3 and the USGS digital line graph hydrography files into a new, more flexible format. Features include:

- State participation in updates to improve the data
- Improved accuracy due to nationwide QA efforts
- Maps that meet national mapping standards
- More extensive feature names
- Stream order or level
- Topologic connectivity
- Centerlines through wide rivers/ lakes for routing
- Improved capability with GIS standards

Complete details on the NHD characteristics and production status is available at <http://nhd.usgs.gov>

Steps in Waterbody Indexing Process

Waterbody indexing of designated uses leads to the development of a GIS coverage containing locations of waterbodies within the RF3/NHD network. The steps in this process are described here using the state of Indiana as an example.

EPA has provided contractor support and/or grants to many states for georeferencing support under several sections of the Clean Water Act. The main EPA goal was to make mapping capabilities more widely available and to promote consistent methods for displaying various waterbody entities.

Steps in Reach Indexing Waterbodies

1. Set priorities and allocate resources.
2. Delineate waterbodies
3. Update relevant database
4. Conduct reach indexing using GIS tools
5. Review and correct draft coverages

It is important that States develop a well-thought-out waterbody delineation scheme before reach indexing is begun. Information (in this case, Water Quality Standards) is linked to each waterbody, so it is important that the spatial area represented by the waterbody exactly match the spatial area to which the information pertains. This is known as spatial determinacy.

There are many ways to correctly delineate waters; the only requirement is that the waterbody IDs be spatially determinant and meaningful to the State. Usually a State prefers to use a delineation scheme with which they are familiar. For example, the State of Indiana did not have waterbodies delineated for Water Quality Standards, but waterbodies had previously been delineated for the 2000 305(b) report. Each of the waterbodies in Indiana's 305(b) report were assigned a unique ID based on the 14-digit watershed ID, or hydrologic unit code (HUC). For example, the 8-digit HUC in Figure 2 is divided into 14-digit HUCs. In some cases where all the reaches related to river features, a single ID will suffice to identify the traces in a 14-digit HUC. Where the small watershed contains lakes, or where it is worthwhile to distinguish mainstream rivers from tributary streams, additional waterbodies may be created within the framework of a 14-digit HUC.

The Indiana General designated use (which includes Aquatic Life, Full Body Contact Recreation, and Agriculture) applies to all of the hydrography within 14-digit HUC INB071a. The waterbody INB071a in Figure 2 would be an appropriate delineation if these were the only uses. However, within this 14-digit HUC is a small stream segment around the intake to a public water works that is designated as Public Water Supply. If we associated the waterbody INB071a with the designated use of Public Water Supply it would appear that all of the waters in that 14-digit HUC are held to the Public Water Supply standard. This is incorrect, but how is the problem corrected?

Subdividing the waterbody into segments provides a way to delineate designated uses that apply to shorter stream reaches. Waterbody INB071a, segment T1025, is a small stream segment within this 14-digit watershed that is designated for both General and Public Water Supply uses. Using this segmented ID scheme, all of the other streams within this watershed would be called INB071a_00. IDs INB071a_T1025 and INB071a_00 are associated with the General designated

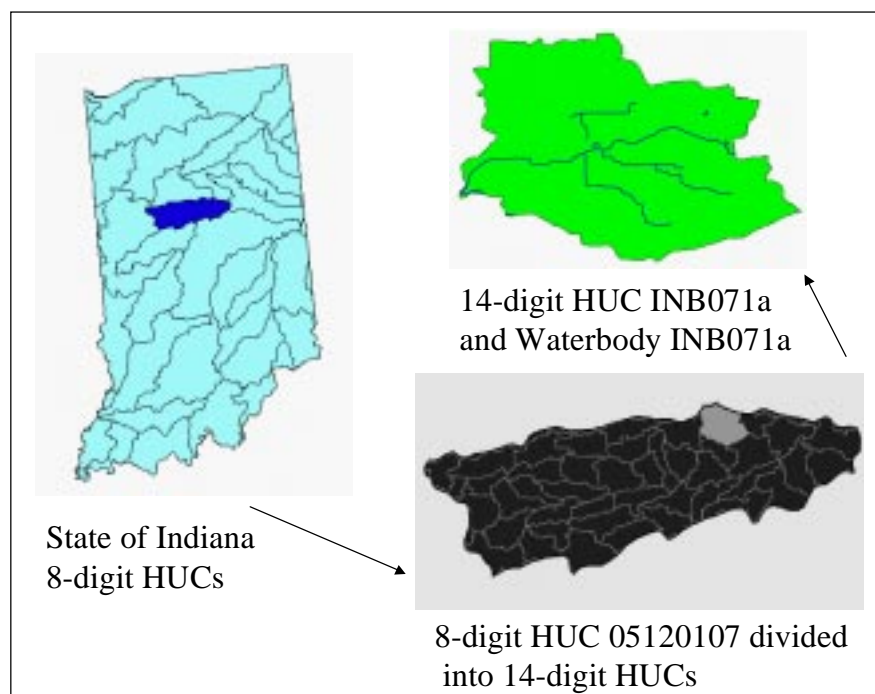


Figure 2. Indiana 305(b) waterbody delineation.

use, and INB071a_T1025 is associated with the Public Water Supply designated use (Figures 3 through 5).

<i>Entity_id</i>	<i>Exceptional</i>	<i>General</i>	<i>Public Water Supply</i>	<i>Outstanding State Resource</i>
INB071A_00		X		
INB071A_T1005		X		
INB071A_T1006		X		
INB071A_T1025		X	X	
INB071B_00		X		
INB071B_T1007		X		
INB071C_00		X		
INB071C_T1026		X		
INB0721_00		X		

Figure 3. Indiana attribute table for 14-digit watershed INB071a.

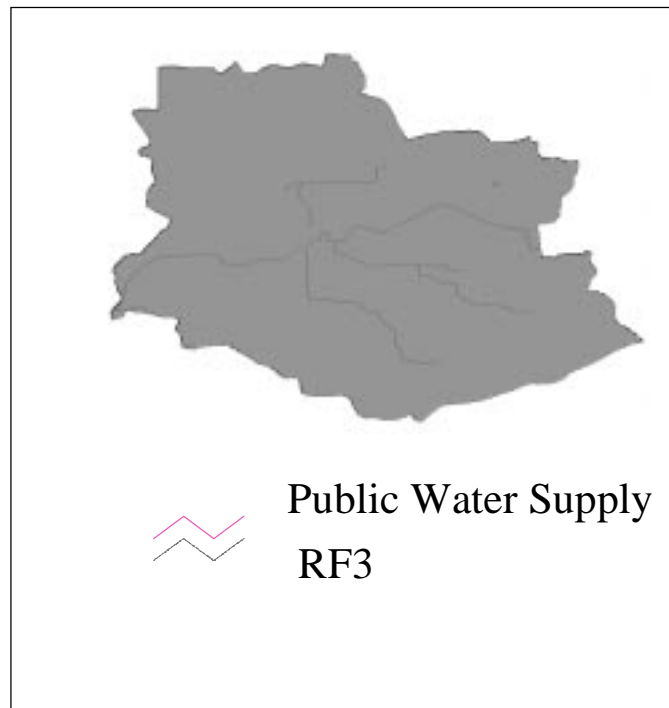


Figure 4. Public water supply in 14-digit HUC INB071a.

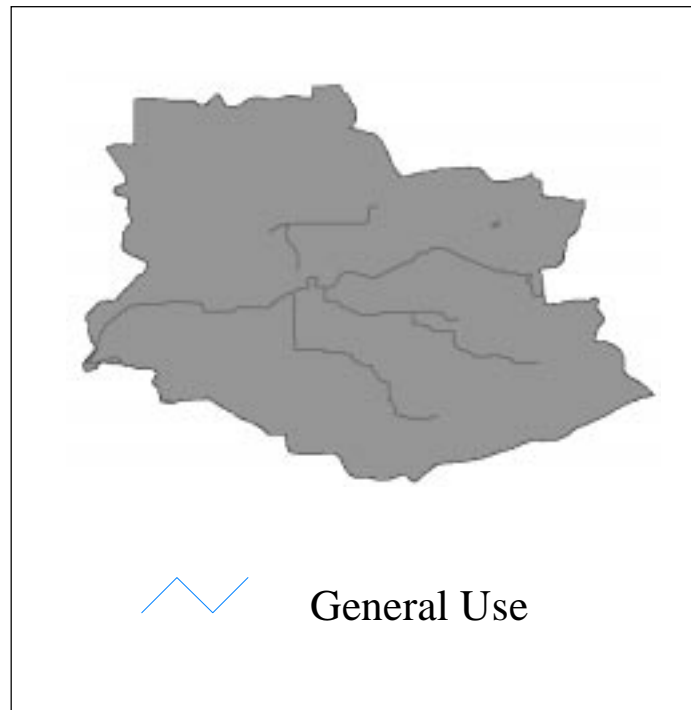


Figure 5. General designated use in 14-Digit HUC INB071a.

Indiana will be delineating their waterbodies for Water Quality Standards on hardcopy maps and the waterbodies will be reach indexed. The State of Indiana Department of Environmental Management intends to delineate waterbodies that can be joined with the WQSDB, the Assessment Database (ADB) for 305(b), and the Total Maximum Daily Load (TMDL) Database for 303(d). This should enable rapid generation of maps for water resources decision making and management.

Water Quality Standards Web Review/QA Site

Once the database and GIS components are developed, they must be reviewed and quality assured (QA'd) by the States to ensure accuracy in both interpretation of the document and waterbody locations. A Web-based Water Quality Standards review site was developed to allow States easy access to the water quality standards coverages so that they could provide corrections and feedback. This site allows States to view their water quality standards displayed in detail on the RF3/NHD surface water coverage. Environmental Systems Research Institute's (ESRI's) MapObjects GIS product and a separate relational database management program were used to develop this customized application. One benefit of this on-line review is that it allows State staff without GIS capability to ensure that the mapping is done accurately. States with GIS capability can download shapefiles of the water quality standards work, either for a more thorough review, or for use with other State initiatives. This password-protected web review site is available only to State water quality standards personnel (public access is anticipated by the fall of 2000 through a separate EPA Enviromapper-based web site.

The following major areas are included in the main web site menu:

- First Time Users provides a slide show that can be viewed online or downloaded. Terms such as waterbody, georeferencing, and spatial indeterminacy are fully discussed. These materials show the benefits of georeferencing waterbodies to a nationally consistent hydrography coverage.
- Reach Indexing leads to a related educational reach indexing web site (<http://georef.rti.org>) where the fundamental concepts of georeferencing and dynamic segmentation are presented in greater detail with demonstrations and examples.
- Begin Review is the site where states can do online review and QA of their designated use coverages (Figure 6). In addition to providing facilities for the online review of water quality standards mapping on the State level, the website provides summaries of the progress of the water quality standards mapping on a national scale (Figure 7), announcements of training opportunities, and other explanatory information for the

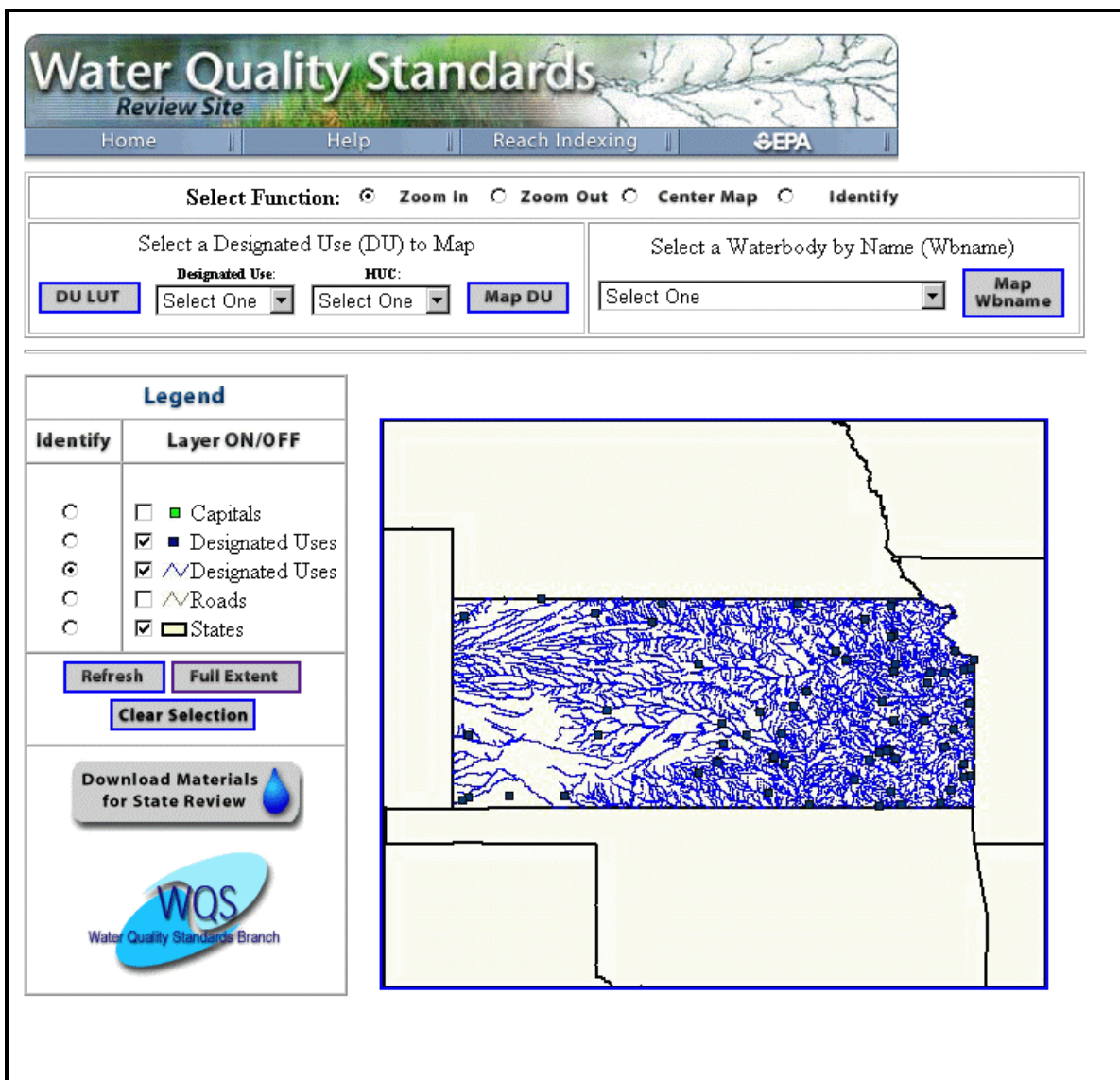


Figure 6 Water quality standards web review site.

progress of the water quality standards mapping on a national scale (Figure 7), announcements of training opportunities, and other explanatory information for the general public.

- EPA provides a link to the Agency's home page.

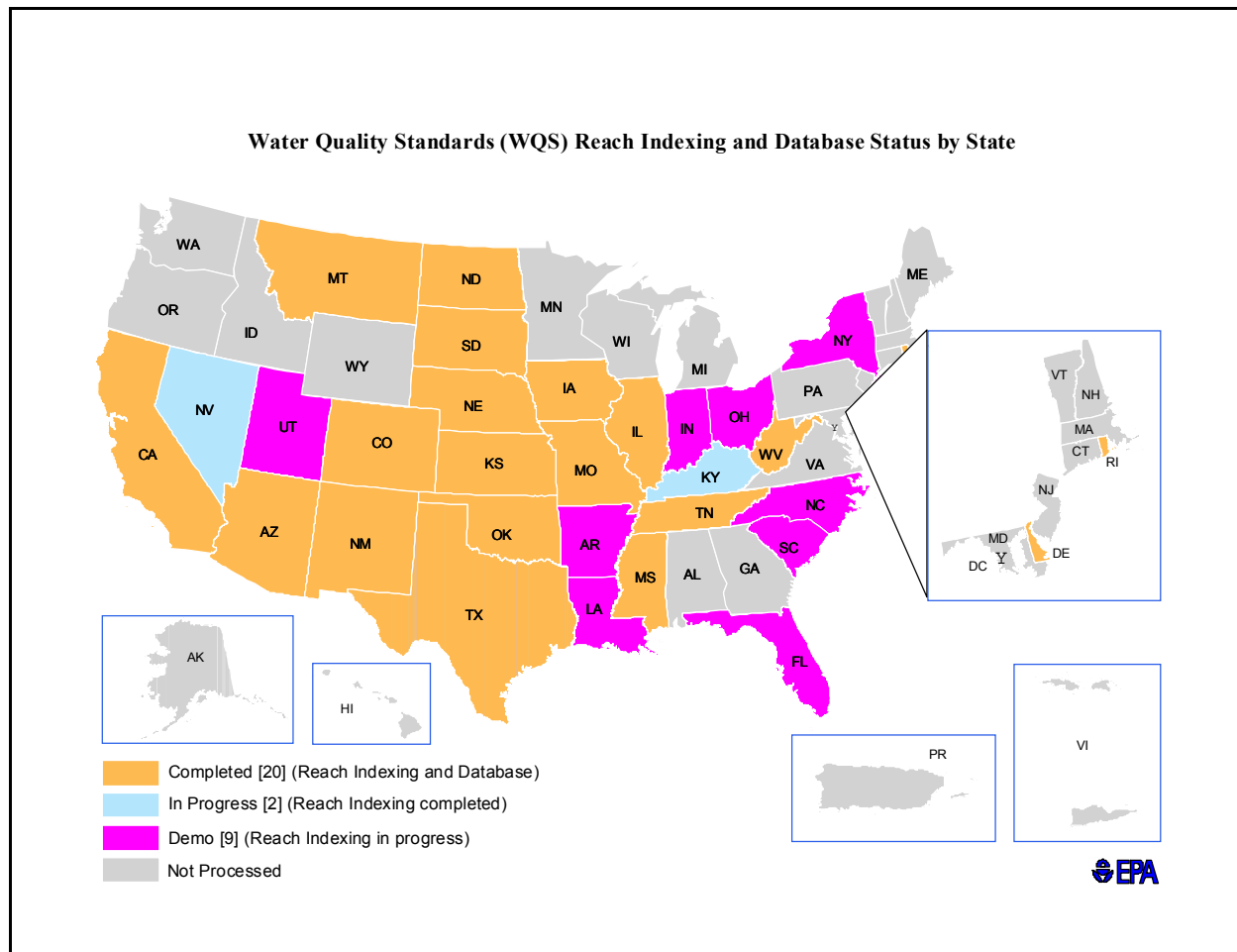


Figure 7. Water quality standards mapping status - Spring 2000.

WQS Web Review/QA Site Capabilities

1. Zoom in / out

Radio button at the top of the page allows the user to zoom in or out from the default view to select a location of interest.

2. Center Map

A Center Map button will redraw the map at the desired center point.

2. *Center Map*

A Center Map button will redraw the map at the desired center point.

3. *Turn layers on/off*

The legend on the left side of the page contains a series of checkboxes next to the spatial data layer names. Clicking the checkbox on or off selects which layers should be displayed in the map.

4. *Identify*

The Identify feature allows you to click on a feature of interest to learn more about that feature.

5. *Map selected designated use*

The “Map selected designated use” function allows you to display all the waterbodies with a specified designated use within a specified HUC. A map will be returned with the waterbodies highlighted in red that meet your selection. This function also returns a table below the map that contains a list of IDs and waterbody names that meet your criteria.

6. *Map selected waterbody name*

The “Map selected waterbody name” function allows you to display all WQS features (linear and point events) with a selected waterbody name.

7. *Download State Review Materials*

The Download State Review Materials button is available just below the legend. This button brings you to another page that allows you to download materials needed to complete the review process:

- Download State level WQS shapefiles
- Download USGS 8-digit cataloging unit (HUC) level WQS shapefiles
- Download a file of the waterbodies that were included in the State's water quality Standards document, but were not located based on provided information.

WQS Web Review Site *Major Functionality*

1. *Zoom in / Zoom out* at point of click

2. *Center Map* - center on point of click

3. *Turn spatial data layers* on / off.

4. *Identify*

Click on a feature of interest and the feature is selected and tabular information displayed below the map.

5. *Map selected designated use*

Choose a Designated Use and an 8-digit USGS cataloging unit (HUC) to display all the waterbodies with the specified designated use within the specified HUC

6. *Map selected waterbody name*

7. *Download* state review materials

8. *Refresh*

9. *Full Extent*

- Download a file of waterbodies and associated uses that are included in the State's water quality standards document.

8. Refresh

The Refresh button allows you to redraw the map. Usually used if you just want to draw/remove layers from the map.

9. Full Extent

The Full Extent button redraws the map at the original extent (showing your entire State).

10. Clear Selection

The Clear Selection button allows you to clear all selected features. Selections are not cleared unless you click this button or perform another selection.

Water Quality Standards Database (WQSDB)

EPA is developing the Water Quality Standards Database (WQSDB) for the purposes of tracking water quality standards (WQS), including designated uses and criteria, for the Nation's surface waters. In the fall of 2000, EPA will release a web-based application providing access to the WQSDB. The application provides five reports allowing users to query the designated use and criteria information in the database. The reports allow users to query on waterbody or designated use within a state, compare designated uses across states, summarize numeric criteria for EPA priority pollutants by state, and compare EPA Nationally Recommended Water Quality Criteria to state criteria. Currently EPA is in the process of reviewing the WQSDB and the reports with states, tribes, and territories to assess future needs.

WQSDB Standard Reports

1. Designated Use Information by State
2. Designated Use Information Across States
3. Waterbody Information
4. State Water Criteria
5. State vs. EPA Criteria

Conclusion

The ability to visualize Water Quality Standards information will help EPA, States, Territories, and Tribes manage their water quality standards data and integrate them into other programs such as 305(b) or 303(d) initiatives. At the same time, this initiative provides more accessible and meaningful data to the public.

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